THE OCCURRENCE OF FUSIFORM BACILLI AND SPIRILLA IN CONNECTION WITH MORBID PROCESSES.*

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DURING the past three years there have appeared many reports of the finding of bacilli of fusiform shape, often associated with long spirilla, in connection with various pathological conditions. The bacillus has been designated variously as "fusiform bacillus," "spindle-shaped bacillus," "bacillus hastilis," "bacillus fusiformis," "Vincent's bacillus," "Bernheim's bacillus," etc.

According to Tarassiewicz (quoted by Mayer), the first observer to note the association of fusiform bacilli and spirilla with a morbid process was Rauchfus. In 1893 he demonstrated pointed bacilli and spirilla in ulceromembranous angina, and his photographs then appear identical with those described by subsequent writers. Plaut in 1894 described the organisms in five cases of ulcerous angina. Vincent in 1896 described fusiform bacilli and large spirilla in cases of hospital gangrene, and stated that the same organisms were found in certain anginas of an ulcerative type. Bernheim in 1897 reported 30 cases of stomatitis and angina, in all of which he had found fusiform bacilli and spirilla. He appears to have been the first to point out the etiological identity of certain cases of stomatitis and angina. Vincent, in 1898, reported a further series of 14 cases of ulceromembranous angina in which the organisms were present. These early reports have been followed by a large number of corroborative observations which testify to the occurrence in preponderating numbers of fusiform bacilli and spirilla in certain cases of stomatitis and angina. A large number of these observations have appeared in French literature, many in the German and American, and a few in the English. This indicates the wide distribution of the organisms in question. The infrequency with which the disease has been recognized has probably been due to failure to make direct examinations of the exudate from pseudomembranous lesions of the mouth and throat. Because diphtheria bacilli are not detected with any certainty by such examinations, the custom of depending upon cultures quite exclusively has become almost universal, and as the fusiform bacilli and spirilla do not grow to any extent upon the medium usually employed for the detection of diphtheria bacilli, they have been largely overlooked.

The fusiform bacilli and spirilla have also been described in connection with hospital gangrene by Vincent and Matzenauer, and the bacilli alone by

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Coyon. The two organisms have been found in association with noma by Matzenauer, Seiffert, Perthes, Rosenberger, and others. The bacilli alone have been noted by many observers in cases of noma. In several instances the organisms have been found in the pus from fetid abscesses about the mouth (Veszprémi, Silberschmidt, Seitz, Lichtwitz, and Sabrazes). Rodella found the fusiform bacilli in the fetid contents of a subpectoral abscess. Silberschmidt observed the two organisms in pus from a necrotic phlegmon of the thigh and from a bronchiectatic cavity, and the bacilli alone in a brain abscess. Veillon and Zuber demonstrated the bacillus by means of pure cultures in two cases of appendicitis, and designated it "bacillus fusiformis." Niclot and Marotte found the bacilli and spirilla in the intestinal contents in a case of dysentery in a dog, and Angelici says that the bacillus is present in various morbid processes throughout the alimentary canal in man and the lower animals. Rona found the two organisms in 15 cases of gangrenous ulcers of the penis.

There appears to be no case reported in which the fusiform bacillus either alone or in association with the spirillum, has been found in connection with a morbid condition in man without the simultaneous presence of other bacteria. Cocci are almost constantly present. In the ulceromembranous anginas, the two bacteria under consideration have been observed in connection with diphtheria bacilli by Abel, Baron, Bernheim, Vincent, Niclot and Marotte, Auchè, Simonin, de Stoecklin, Gallois and Courcoux, and Oberwinter. Abundant fusiform bacilli, but no spirilla, were found together with diphtheria bacilli in one case by Beitzke and in six cases by Oberwinter. The latter author also observed three cases of diphtheria in which smears showed almost only fusiform bacilli and spirilla. That the organisms occur in syphilitic lesions of the mouth and tonsil is shown by the observations of Baron, Vincent, Freyche, Graupner, Hallopeau and Apert, Salomon, and Wolf. Hallopeau and Apert believe that these organisms may locate upon wounds, as after tonsillotomy, or upon the gums of scorbutics, and may complicate mercurial stomatitis.

Abel was successful in demonstrating both varieties of bacteria in healthy mouths, especially between the gums and teeth. Gross found bacilli and spirilla in small numbers upon the normal tonsils of 11 of 13 persons. It is generally stated that the spirilla described in these cases are the "spirochaeta denticola" of Miller. Corresponding spirilla were found by Rona in small numbers on healthy genitalia, and Rosenberger found spirilla closely resembling those in ulcerative angina, but without the associated bacilli, in the vaginal secretion of children and adults.

In most of the cases, the bacilli and spirilla have been recognized in smear preparations made from the seat of disease, and in stained microscopic sections of tissues. Usually efforts to cultivate the organisms have resulted in failure. A number of investigators have grown the bacilli in mixed cultures: Angelici in media containing acetic acid, Gross in ascites serum, Niclot and Marotte in media containing sera, Seitz in ordinary broth and in the water of condensation in serum-agar tubes, Silberschmidt in broth and ascites-broth, Veszprémi in broth mixed with various sera, Seiffert, Perthes, and Brüning in deep agar tubes. Some of these authors also obtained a

simultaneous growth of spirilla; Niclot and Marotte in pleural fluid and broth, and other mixtures of sera, Silberschmidt in broth containing one per cent of acetic acid, Veszprémi in media containing rabbit serum, Seiffert and Perthes in agar, Netter in ascites fluid and defibrinated pleural fluid. There does not appear to have been any successful pure cultivation of the spirilla. Pure cultures of fusiform bacilli have been obtained by Veillon and Zuber, and by Ellermann.

The present description is based upon the study of the organisms from the following sources: Three cases of ulceromembranous stomatitis; five cases of ulceromembranous angina; two cases of combined angina and stomatitis; one case of noma of the cheek; one case of diphtheria; saliva and tartar from 18 healthy mouths. Three of these cases, one of angina and one of stomatitis, and the one of diphtheria, occurred in the department of contagious diseases of the Cook County Hospital in the service of Dr. Wm. L. Baum. Most of the other cases were observed in the hospital of the Memorial Institute for Infectious Diseases, in the service of Dr. Frank Billings and Dr. Alexander F. Stevenson. To these gentlemen we wish to express our thanks for the opportunity to study the cases. Two cases were observed in private practice.

The clinical side of the subject will be reserved for a separate report, and the case of noma will be dealt with in detail at a future time.

EXAMINATION OF MATERIAL FROM THE LOCAL LESIONS.

In smear preparations made from the seat of disease, bacilli and spirilla were found which corresponded with those described by other authors.

The bacilli are long, slender rods with pointed ends, somewhat larger in the middle. Sometimes the ends are rounded and the rod is rather thick. The rods are sometimes slightly bent, and occasionally take the form of the letter S. The length is usually from 6 to 12 μ, but sometimes filiform elements of considerable length are encountered. The bacilli are usually scattered quite uniformly throughout the preparation, and often occur as pairs end-to-end, sometimes forming more or less obtuse angles. At times they are seen in irregular clumps, or arranged radially about a common central point, or in rows somewhat similar to

diphtheria bacilli. They stain fairly well with Loeffler's solution of methylene blue and anilin-water solution of gentian violet, but best with carbolfuchsin. With the less intense stains, especially in the larger forms, there are often portions of variable size and shape which stain faintly. These have been described by many observers, and sometimes spoken of as vacuoles. They have also been mistaken for spores, but they do not stain like spores. Vincent has described giant forms of the bacilli. With Lugol's solution of iodine there is no staining, nor starch granules. As stated by Gross, the bacilli contain no Ernst granules. No motility could be detected. This corresponds to the statements of most authors (Vincent, de Stoecklin, Niclot and Marotte, and others). Some observers, however, describe the bacilli as motile (Baron, Abel, Bernheim, Graupner, Hess, Sobel and Herrman). Graupner has illustrated the bacilli with stained peritrichous flagella. He found that motility was rapidly lost, even under favorable conditions in 20 minutes. Beitzke explains the varying expressions regarding motility by this fact, but it is better accounted for by Ellermann, who cultivated the shorter, curved forms in pure culture, and found them to be motile spirilla.

The bacilli do not stain by Gram's method. Several authors say that rather prolonged action of alcohol is required to accomplish complete decolorization. Vincent, Abel and Niclot and Marotte say that it is stained by Gram's method, but this is contradicted by all other authors.

The number of bacilli is variable. In the earlier stages of ulceromembranous angina and stomatitis, they are most abundant, and decrease as the process of recovery advances. When the bacilli and spirilla are most abundant, other forms of bacteria are present in small numbers. As the two organisms decrease, the associated bacteria usually increase. In normal mouths the fusiform bacilli are present in small number in smears from the saliva, tongue and gums. In the case of diphtheria they were to be found only after considerable search.

The spirilla, also spoken of as spirochaetae, which are associated with the fusiform bacilli in a large proportion of instances, are long, delicate, and present three to six or eight turns. They

stain uniformly, and much less intensely than the bacilli, and in faintly-stained preparations might be overlooked. They do not stain by Gram's method being much more quickly decolorized, than the bacilli. They are usually quite actively motile, but sometimes not. Vincent says that some are immobile or only slightly motile, while others are very actively motile. Niclot and Marotte state that they rapidly lose their motility when exposed to cold. The association of spirilla with the bacilli was observed in all the cases studied. In general their number corresponded to the number of bacilli. In the mouths of many healthy persons, what appeared as the same spirilla were found, especially about the gums, often in enormous numbers.

Most authors believe the fusiform bacilli and spirilla to be entirely distinct varieties of bacteria and that they act in symbiosis, the spirilla serving to enhance the virulence of the bacilli. Vincent, Niclot and Marotte, Baron, Hess, Oberwinter, etc., have observed that those cases of ulceromembranous angina in which only the bacilli are found are milder than those in which the two organisms are associated. In cases in which deeper destruction of tissues occur, the spirilla are said to be constantly present. In the case of noma from which material for study was obtained, fusiform bacilli and spirilla were present in the nasal discharge from the beginning, and later in the ulcerative lesions of the gums and cheek.

Some observers have maintained that the bacilli and spirilla are different forms of one organism (Seiffert, Perthes, Sobel and Herrman, and Krahn). After careful examination of many preparations, both direct from man and from pure and mixed cultures, the writers have been unable to find any evidence to support these assertions. Most authors consider the bacilli and spirilla distinct organisms.

MIXED CULTURES OF FUSIFORM BACILLI.

In some of our earlier aërobic cultures it was observed that there was a slight growth of bacilli in the fluid of condensation at the bottom of tubes of Loeffler's blood serum mixture, and in tubes of ascites fluid. It was soon found that they grew best in sugar-free broth, either alone or combined with horse serum or ascites

fluid. Angelici says that sugar inhibits the growth of the bacilli in mixed culture, and Niclot and Marotte found that they did not grow in sugar broth. After dextrose-free broth was employed, there was no failure in obtaining the bacilli in association with cocci, and almost always streptococci. In aërobic cultures in dextrose-free broth made direct from materials containing the bacilli there was little increase of the bacilli during the first 24 hours. During the second 24 hours there was a great increase, even when the inoculated material contained very few bacilli, as in saliva from healthy mouths, and from the case of diptheria. The cultures then emitted a foul odor. Coverslip preparations showed fusiform bacilli together with other bacilli and especially with cocci. The bacilli presented about the same appearances as they did in smears made direct from the patient. The reaction of the culture fluid after 48 hours was alkaline to litmus. In a mixture of ascites fluid and dextrose-free broth (one to three) the growth was similar to that just described but the fetid odor was more pronounced. Most authors mention the foul odor of such cultures. In one lot of ordinary nutrient peptone broth, there was abundant growth of the bacilli in mixed cultures, while in another lot there was no apparent growth. The growth in the water of condensation at the bottom of tubes of Loeffler's blood serum mixture was variable, sometimes succeeding in a limited degree, and again failing.

In dextrose-free broth the fusiform bacilli grew in mixed cultures with no exclusion of oxygen. In this respect the fusiform bacilli resemble many other anaërobes which grow readily in association with suitable aërobes in fluid media without exclusion of oxygen. In the mixed cultures described, the fusiform bacilli rapidly die, after a week or 10 days scarcely any can be detected. The fusiform bacilli did not increase appreciably upon solid media in mixed cultures with or without the exclusion of oxygen.

The fusiform bacillus was grown in cultures in association with other bacteria from the following sources: Two cases of ulceromembranous stomatitis; four cases of ulceromembranous angina; one case of combined angina and stomatitis; one case of noma; one case of diphtheria and 13 normal mouths.

MIXED CULTURES OF SPIRILLA.

The spirilla were grown in combination with fusiform bacilli, streptococci and the other bacteria from a tonsillar concretion, and from tartar from six healthy mouths. The inoculated material contained many spirilla. The medium employed was human pleuritic exudate and broth in one case, and in the others broth which contained no fermentable sugar, but a small amount of muscle sugar. The increase of spirilla was always limited, and the exclusion of oxygen did not appear to influence the growth. In one instance a subculture was successful. The spirilla were not grown on solid media, and never in pure culture.

PURE CULTURES OF FUSIFORM BACILLI.

Pure cultures of fusiform bacilli were obtained from three cases as follows: One case of ulceromembranous angina; one case of ulceromembranous stomatitis; one case of diphtheria of the tonsil. In the cases of stomatitis and angina the fusiform bacilli and spirilla were very numerous in smear preparations from the exudate; both were typical cases clinically. In the case of diphtheria the bacilli were present in small numbers in the smears. Typical diphtheria bacilli were cultured from this case in abundance, and there was a prompt improvement after the administration of diphtheria antitoxin. In the two former cases, material from the local disease was smeared over the surface of a series of slants of horse-serum-agar. After anaërobic growth at 37° for three to five days, the colonies of fusiform bacilli appeared as very delicate, whitish disks one to two mm. in diameter, resembling colonies of streptococci. By inoculation from such colonies pure cultures were obtained. In the case of diphtheria a culture was first made into sugar-free broth and ascites fluid (three to one), and when the bacilli had become abundant, smear cultures were prepared upon slants of serum-agar, as in the other case. Unsuccessful efforts were made to obtain pure cultures from a few other cases. In a 48-hour broth culture containing a great number of the bacilli, a good many are probably already dead, as very few colonies develop when the broth culture is smeared over serum-

agar slants. In many instances colonies were found to contain the bacilli and streptococci in association.

The three pure cultures possessed the following characteristics:

CULTURAL AND BIOLOGICAL PROPERTIES.

They were obligate anaërobes, and grew at 36°, but not at all at room temperatures. They were non-motile.

All the cultures in the following description were grown by Wright's method, by saturating the cotton stopper with a strong solution of pyrogallic acid in a five per cent solution of sodium hydroxid, and closing the tube with a tightly fitting cork, sealed with paraffin.

Slant of horse-serum agar. After 24 or 48 hours a delicate, whitish, confluent growth appears over the inoculated surface. In the water of condensation the flocculent growth collects at the bottom, leaving the fluid clear.

Slant of ascites-agar. At the end of 24 to 48 hours there appears a delicate continuous, white growth, frequently with delicate colonies, one and two mm. in diameter along the edge of the streak. A flocculent growth collects at the bottom of the fluid of condensation.

Loeffler's blood serum. In 24 hours a barely perceptible growth appears along the line of inoculation, which increases for three or four days. At its maximum growth it is slightly moist, a little irregular, or granular on the surface, continuous, resembling much some streptococcus cultures.

Agar slant. In the first 24 hours there is no visible growth. In 48 hours there forms a very delicate, whitish growth, limited to the line of inoculation, and appearing as a cloud upon the surface.

Glycerin agar slant. After 24 or 48 hours there appears a very delicate, whitish, cloudy growth upon the surface, following the line of inoculation, with pin-point sized colonies at the border. The growth here is less abundant than upon plain agar, and the agar looks as if it had become opaque where the growth is located. One of the cultures failed to grow upon this medium.

Stab in glucose agar and ascites fluid (three to one), with a layer of water agar above. Beginning in 24 hours, and increasing for three days, an abundant, grayish-white, opaque growth develops all along the needle track. There is no gas formed.

Glucose agar stab (with overlying layer of water agar). The growth is similar to the preceding but less profuse. There is no growth unless considerable culture is inoculated.

Litmus milk. No appreciable growth of bacilli occurs.

Litmus milk and ascites fluid. After a week there is a growth of bacilli, the medium being decolorized in two days. When oxygen was admitted, the medium gradually assumed a red color.

Potato smeared with ascites fluid. No growth.

Egg. An unbroken egg was inoculated through a small opening with proper precautions to prevent contamination, and the opening sealed. After seven days the white of the egg was turbid, the yolk fluent, and there were present abundant fine bacilli and filaments. The latter were sometimes stained irregularly in segments with carbolfuchsin, causing an appearance suggestive of streptococci. There was no foul odor.

Dextrose-free broth. A slight flocculent growth appears after 24 hours. This increases for three or four days, and settling to the bottom, leaves a clear fluid above. On agitation the growth rises as a rope at first, but is readily distributed throughout the fluid without visible granules.

Dextrose-free broth and ascites fluid (three to one). The growth is similar to the preceding but more abundant. The upper fluid retains a slight smoky opacity or opalescence.

Dextrose-free broth and horse serum (three to one). The growth is similar to the former but the upper fluid is apt to be perfectly clear.

Plain nutrient broth. There is no growth. Acetic acid added to broth seemed to interfere with rather than to aid the growth of the bacilli. All the cultures upon media containing blood serum and ascites fluid gave off a very offensive odor. Filter-paper moistened with a dilute solution of lead acetate is turned brown in the upper part of such culture tubes, indicating the production of sulphides.

If varying amounts of glucose are added to tubes of sugar-free broth, it is found that the bacilli do not grow when the percentage of glucose is 0.5 per cent or higher. If the proportion is 0.25 per cent or less, growth occurs. If, however, ascites fluid is mixed with the broth, growth occurs when two per cent of glucose is present.

Two of the cultures were inoculated into plain broth without and with the addition of one and two per cent glucose, dextrose, levulose, and lactose, and two and five per cent glycerin. In none was there any growth after 24 hours. Corresponding tubes with one-third the bulk of ascites fluid added showed abundant growth after the same length of time. After a longer time in levulose broth there is usually a limited growth.

The results of the aërobic growth of the fusiform bacillus alone and in association with two other bacteria in sugar-free and one per cent dextrose broth is shown in the accompanying table.

Cultures			Media	After 48 Hours Growth	
Bac. fusiformis	Streptococcus from angina	Pseudodiph. bac. fr. case of noma		Reaction to Litmus	Cover-slip preparations
+	−	−	Sugar-free broth	Faintly alkaline	Very few fusiform bacilli
+	−	−	1% dextrose broth	Faintly alkaline	No growth
+	+	−	Sugar-free broth	Strongly alkaline	Moderate increase of bac. Much increase of strep.
+	+	−	1% dextrose broth	Strongly acid	No bacilli Great increase of strep.
+	−	+	Sugar-free broth	Strongly alkaline	Great increase of fusiform bac. Few pseudo-d. bac.
+	−	+	1% dextrose broth	Strongly acid	Slight or no growth of fusiform bac. Great increase of pseudodiphtheria bac.

These results seem to explain why the fusiform bacilli sometimes fail to grow in mixed cultures when the nutrient fluid contains sugar, the rapid production of acid by streptococci and other bacteria preventing growth of the bacilli. The outcome in such cases would depend upon the varieties of bacteria simultaneously inoculated. Varying amounts of sugar in ordinary nutrient broth may account for varying degrees of resulting acidity, and so for growth or failure of growth of fusiform bacilli in such media when inoculated with material containing various bacteria together with the bacilli.

The viability of the cultures was not reduced after repeated transplantations for three months.

MORPHOLOGY AND STAINING PROPERTIES.

In dextrose-free broth there are delicate pointed rods, staining uniformly, usually straight, sometimes bent. They are like those in smears from the local diseases, but not so large in the center, being of nearly the same diameter throughout. Similar bacilli occur in cultures upon plain nutrient agar and ascites agar. In ascites-broth and horse-serum broth the bacilli are slender, with rounded ends and center not enlarged, varying much in length from short forms to longer filaments, often in pairs, end-to-end or in longer chains, usually straight, sometimes bent and wavy. They stain evenly and intensely with carbolfuchsin. When they have grown upon slants of ascites-agar, horse-serum-agar and Loeffler's blood serum mixture they appear as long delicate filaments. With carbolfuchsin they stain rather faintly, but within the rods at irregular intervals are seen deeply stained round or oval bodies. Some filaments are larger than the average, and sometimes the appearance suggests the lateral fusing of two or three filaments, giving rise to giant forms. Sometimes branching was suggested, but none could be with certainty detected. In Loeffler's serum cultures there were sometimes long, filamentous forms which exhibited alternate deep and faintly stained segments, looking like a string of short bacilli. In cultures upon all solid media, there occur individuals which stain faintly, containing the more deeply stained round bodies. Cultures upon ascites-agar sometimes show only evenly stained, short and medium long rods with pointed ends, like those occurring in sugar-free broth. Methylene blue stains the rods fairly well, and after staining with Loeffler's solution, the more deeply stained bodies appear as when carbolfuchsin is employed.

They did not stain by Gram's method, but unless thoroughly decolorized with alcohol they retained a very faint, bluish color.

The bacteria which have been cultivated in pure culture and described as fusiform bacilli, may be discussed somewhat in detail.

Veillon and Zuber in 1898 described the "bacillus fusiformis," which they obtained from two cases of appendicitis. It was a non-motile, obligate anaërobe, which did not form spores, and grew at room and body temperature. In pus it occurred as large, spindle-shaped rods, often in pairs. In cultures it was usually similar in form, but also presented elongated, swollen and granular forms. It stained poorly with anilin dyes, and not at all by Gram's method. It grew rapidly in sugar-agar; after 24 hours small whitish colonies appeared, which later became gray and brownish. The colonies were lenticular, opaque and sometimes became quite large. There was limited formation of foul gas. Gelatin was not liquified. Broth rapidly became markedly cloudy with a dense sediment. In guinea pigs and rabbits it caused small abscesses which healed.

Ellermann in 1904 reported the first successful cultivation of a fusiform bacillus from cases of ulcerous angina and stomatitis. It was a non-motile, obligate anaërobe. In cultures it appeared as slender, straight rods, with pointed ends, often in pairs, usually 5 to 12 μ long, and occasionally as very long filaments. Swelling at the center was not usual. The bacilli stained poorly and unevenly, and were not stained by Gram's or Weigert's methods. They contained no Babes-Ernst granules.

The nutrient medium employed was serum-agar (two parts of agar and one part fluid horse-serum). Colonies appeared after two days, reaching a size of 1 to 1.5 mm. The smaller had a felted appearance; larger ones were circular, and the largest were often prismatic and of a pale yellowish color. The nutrient medium became cloudy. The cultures possessed an offensive odor, but gas bubbles rarely formed. In serum-broth after 24 hours, large, white flocculi formed which later sank to the bottom. Upon the surface of serum-agar there developed small colonies

resembling those of streptococci, or a finely granular, continuous growth. There was no growth upon ordinary agar or broth. The viability was not reduced after nine transplantations.

These two reports are the only ones found which deal with pure cultures of bacilli which resemble the ones described in this paper, Each description is at variance in certain particulars from the other and from the one herein presented, and it is difficult to decide whether the same organism has been studied in each instance or not. In the absence of accurate information as to the variability of certain physiologic properties in these bacteria it is not possible to decide whether certain differences are permanent and essential. In agar cultures, the amount of bacteria inoculated is important.

It appears that at least the organisms studied by Ellermann are the same as those here described.

INOCULATION EXPERIMENTS.

Pure cultures of the bacilli were injected subcutaneously and into the muscles in rabbits and guinea pigs without any result. Veillon and Zuber, with pure cultures of the "bacillus fusiformis" produced small abscesses in rabbits and guinea pigs, which healed. Ellermann does not appear to have tested the pathogenic properties of his cultures.

With the mixed cultures containing fusiform bacilli, we have produced abscesses in guinea pigs by intra-muscular injection. The pus contained the bacilli together with cocci and they were again cultivated from the pus in impure growth. A mixed culture from a case of extensive ulceromembraneous angina was injected subcutaneously in the ear of a small, sickly rabbit. There resulted an extending gangrene of the skin, terminating in the animal's death. After death no fusiform bacilli or spirilla could be found, but only diplo- and streptococci. Mixed cultures containing a growth of fusiform bacilli and spirilla were also injected into the muscles and subcutaneous tissues of guinea pigs with resulting formation of abscesses. In the contents of such abscesses bacilli and spirilla were present and were again cultivated together with cocci. If cultures contained no spirilla, but only fusiform bacilli with cocci, the results were similar.

RELATION OF FUSIFORM BACILLI AND SPIRILLA TO MORBID PROCESSES.

The injection into experimental animals of morbid materials containing fusiform bacilli, with or without spirilla, obtained from infected wounds, in hospital gangrene (Matzenauer, Vincent, Coyon), from necrotic tissues in noma (Guizzetti, Perthes), from ulceromembranous angina and stomatitis (Niclot and Marotte, Carnot and Fournier, Graupner), and from fetid abscesses (Silberschmidt and Veszprémi) have often been followed by localized necrosis and formation of abscesses. Similar results have been noticed to follow the injection of mixed cultures from the same sources. The materials and cultures which have been injected have always contained, not only fusiform bacilli with or without spirilla, but also various other bacteria among which usually have been included cocci, and often streptococci. When such materials are injected it is obviously impossible to determine which of the many forms is most largely responsible for the result. With our accurate information regarding the action of the pyogenic cocci, and their power to produce necrosis and suppuration, it would be reasonable to assume that they are responsible for the results, at least in part.

The strongest evidence in favor of a causal relationship between the fusiform bacilli and the necrotic processes with which they are associated has been furnished by the microscopic examination of the sections of the involved tissues. In tissues from noma cases, filamentous organisms have been demonstrated by many observers at the line of advancing necrosis. Here they are found in great numbers, and a few are also seen in the tissues which are still not visibly altered. Gross and Krebs have also made similar observations in tissues from ulceromembranous angina. The filamentous organisms described by many authors, and studied by us in nomatous tissues bear a close resemblance to the form assumed by the fusiform bacilli in certain artificial pure cultures, as described in this report. The identity of these bacteria in the tissues with the fusiform bacillus cannot be said to be indisputably established.

It is not unlikely that future study will show that what have been spoken of as "fusiform bacilli" are not a single variety of

PLATE 16.

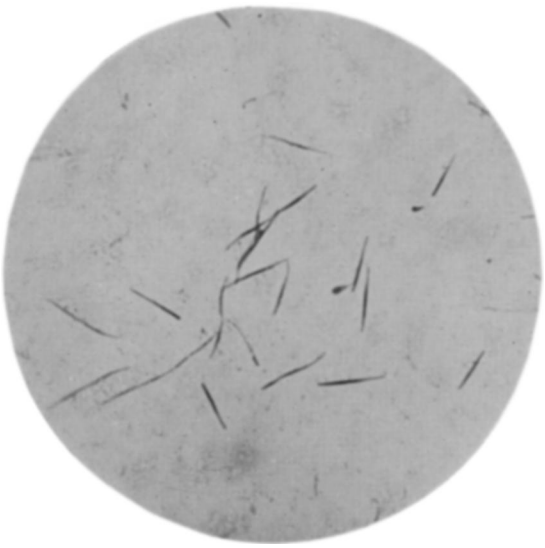

FIG. 1.

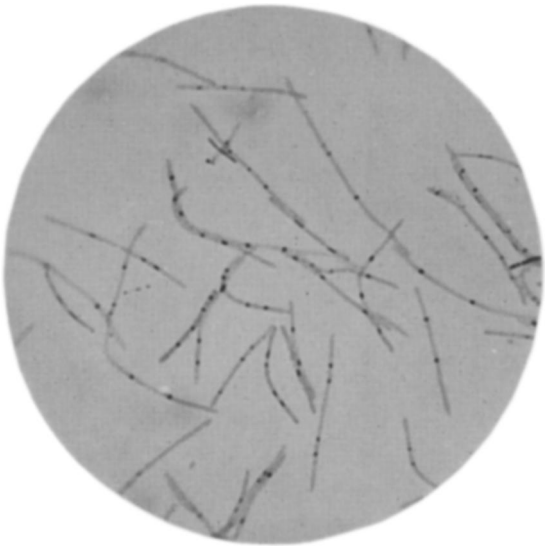

FIG. 2.

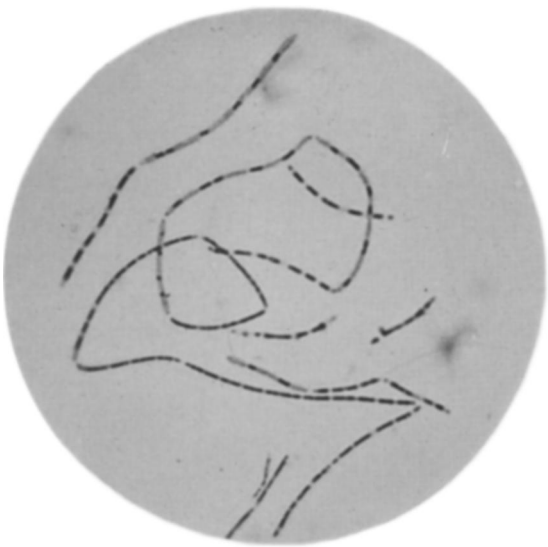

FIG. 3.

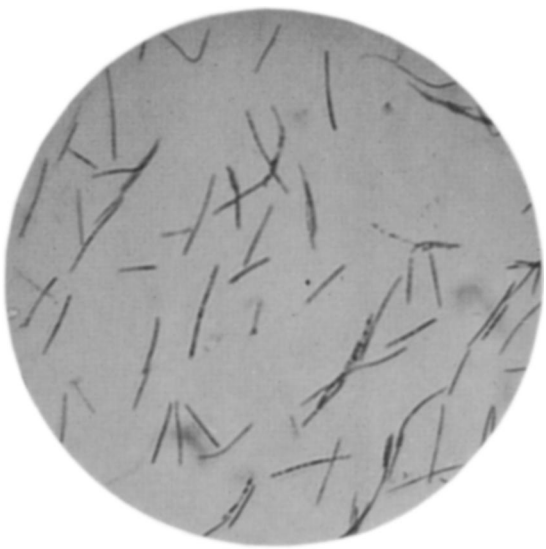

FIG. 4.

bacterium, but represent several distinct varieties as suggested by Beitzke. Now that the common statement that these organisms cannot be grown in pure culture has been shown to be false, it may be hoped that further study with pure cultures will shed light upon the relationship of the bacteria to the diseases with which they are associated.

Note.—Since the above was completed and presented before the meeting of the American Association of Pathologists and Bacteriologists, April 21, 1905, there has been received a further contribution by Ellermann (*Centralbl. f. Bakt.* Abt. 1, Originale, 1905, 38, p. 383.) to whose preliminary report reference has already been made. In the tissues of the uvula from a case of ulceromembranous angina, and in those from a case of gangrenous stomatitis, he found fusiform bacilli in the zone separating necrotic and living tissues. In the latter case spirilla in abundance were also demonstrated in this location. These observations are in agreement with those of previous observers in noma and of Gross and Krebs in ulcerative angina. Ellermann has also produced small abscesses in rabbits with pure cultures of the bacillus.

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In connection with his excellent résumé of the literature bearing upon the fusiform bacillus, Beitzke (*Centralbal. f. Bakt.*, Abt. I., Referate, 1904, 35, p. 1) has collected references to 113 publications. We have given only those to which we have referred and which are not found in his list.

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EXPLANATION OF PLATE 16.

(Photomicrographs of smears stained with carbolfuchsin; × 1200.)

FIG. 1. Pure culture of fusiform bacillus grown five days anaërobically in dextrose-free broth.

FIG. 2. Pure culture of fusiform bacillus grown three days anaërobically on ascites-agar slant.

FIG. 3. Pure culture of fusiform bacillus grown three days anaërobically on Loeffler's blood-serum.

FIG. 4. Pure culture of fusiform bacillus grown three days anaërobically on ascites-agar slant.